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MONITORAMENTO DE COMPOSTAGEM EM PEQUENA ESCALA

MONITORING OF SMALL SCALE COMPOSTING

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RESUMO

O aumento na produção de resíduos sólidos motivou a criação de novas tecnologias para a disposição de lixo e esgoto. Os resíduos orgânicos representam 50% de toda a produção de resíduos sólidos nas cidades brasileiras, no entanto, a maior parte é descartada incorretamente. Uma solução para esse problema é o processo de compostagem, que converte resíduos biodegradáveis em matéria orgânica higienizada e estabilizada e pode ser usado como fertilizante na agricultura e em hortas domésticas. Assim, o presente trabalho teve como objetivo quantificar a composição de nutrientes de uma compostagem de pequena escala e analisar todo o processo de produção. Para isso, foram criadas cinco janelas com 1m³ de composição diferentes, variando entre 30 e 70% da poda e comercializando resíduos orgânicos. Os resultados mostraram que as janelas variaram de 49,9 a 56°C, o pH foi 9, enquanto os parâmetros inorgânicos e orgânicos eram semelhantes aos da compostagem convencional. Concluiu-se que a compostagem em pequena escala é uma alternativa viável ao descarte de resíduos sólidos.

Palavras-chave: Meio Ambiente. Resíduos sólidos. Sustentabilidade.

ABSTRACT

The increase in solid waste production has motivated the creation of new technologies for the disposal of waste and sewage. Organic waste represents 50% of all solid waste production in Brazilian cities, however, most of it is incorrectly disposed of. A solution to this issue is the composting process, which converts biodegradable waste into sanitized and stabilized organic matter and can be used as fertilizer in agriculture and in domestic gardens. Thus, the present work aimed to quantify the nutrient composition of a small-scale composting and analyze the entire process. To perform this, five windrows with 1m³ were created with different composition each, varying from 30 and 70% of pruning and market organic waste. The results found that the windrows varied form 49.9 to 56°C, the pH were 9, while the inorganic and organic parameters were similar to conventional composting. It was concluded that small scale composting is a viable alternative to solid waste disposal.

Keywords: Environment. Sustainability. Solid waste.

1 INTRODUCTION

The increases in solid waste production has motivated the creation of new technologies to garbage and sewage disposal. According to ABRELPE (2011), only in the city of Aracaju, located in the state of Sergipe, Brazil, are generated 592 $ton.day^{-1}$ of garbage. Moreover, it is estimated by ABRELPE (2011) that around 50% of this waste could be recycled using composting processes.

This process converts biodegradable waste into sanitized and stabilized organic matter (ZHANG et al., 2012). Due its valuable nutrient composition to agriculture, composting is nowadays considered as an efficient alternative to reduce the high costs of transportation and disposal of municipal solid waste, preventing environmental and health issues created by its incorrect disposal (HECK et al., 2013).

When composting process is finished, the garbage pile is reduced to approximately 50% of its original volume due the microorganism aerobical and anaerobical processes.

Consequently, the composting of non-hazardous organic wastes reduces significantly the costs of its transportation after disposal to countryside (PEIXOTO et al., 1989). According to BNDES (2006), more than 50% of Brazil area is rural and the availability of fertilizers composed by Nitrogen, Phosphorus and Potassium is scarce, creating an ideal scenery for the organic fertilizers uses.

Only in 2005, the importation costs of Potassium chloride were more than 1 billion reais, which is approximately five millions fertilizer tons (BNDES, 2006). According to Kiehl (2002), organic composting fertilizers contains such macronutrients that could replace chemical fertilizers, beyond improve physical soil properties and avoids environmental pressures caused by improper disposal of waste. Thus, the composting methods are an effective solution to reduce the problem of waste management in a global scale.

The process extent to produce a good qualities products can change according to the type of waste and the system size. Different processes are adopted to accelerate the composting process and product development (NAIR; OKAMITSU, 2010). To enhance soil fertility, it has become a common practice the use of organic matter, such as residues from food industry, manure and sewage sludge (BUSTAMANTE et al., 2010; BURLE et al., 2014).

Finally, composting can be made in different scales from industrial to home sizes. Nowadays, it is a common practice to people separate their organic waste and from it produce organic fertilizer in small scale composting. The main environmental advantage of home or small scale composting in relation to large ones, is that the first does not need transportation and sorting costs (ANDERSON et al., 2011). Aiming through the monitoring and process analysis of small-scale composting, the present study objected to quantify the nutritional composition of the biofertilizer.

2 METHODS

2.1 Building the Composting Windrows

The experiments were conducted in an area of 50 m^2 above the soil, denominated by Balcony Composting, which belongs to the Laboratory of Catalysis, Energy and Materials - LCEM, located in the Institute of Technology and Research - ITP, in the city of Aracaju - Sergipe. The windrows dimensions were 100 cm long, 100 cm wide and 100 cm high (process on a small scale), following the method of aerated piles tilling in outdoor sites. The windrows were organized in alternated layers of about 15 cm, composed by crushed organic waste, obtained from the cafeterias and restaurants and tree pruning from Campus II of UNIT and street markets in the city of Aracaju. The composition of the windrows were: Windrow 1 (70% street market and 30% of waste from pruning); Windrow 2 (60% and 40%); Windrow 3 (50% and 50%); Windrow 4 (40% and 60%); and windrow 5 (30% and 70%) respectively.

2.2 Samples and Collections

The garbage collections were carried out by following the methodology of quartering according to NBR No. 10,007 (2004), withdrawing a rate of 100 g of material which was brought to the greenhouse at 50°C for 40 min to stop the fermentation process, and then was stored under refrigeration at 4°C.

2.3 Monitoring of the Process

During the composting process, analyzes of the following parameters were performed:

Temperature: it was measured at room temperature and the windrow composting using a digital thermometer Minnipa-APPA of MT-520 model equipped with a aluminum thermocouple with 25 cm length. Measurements were performed at five different points along of each windrow and the temperature value was expressed as the mean scores.

pH: A sample of 20 g of compound was homogenized with 30 ml of distilled water and the pH of this solution was measured, in triplicate, in a digital potentiometer (Digmed) according to the methodology of EMBRAPA (2009).

Total Nitrogen: the experiments were performed in triplicate using the Kjeldahl method described by Siqueira (2006).

Vegetable fibers: the concentrations of cellulose, hemicellulose and lignin were performed by the van Soest method (SIQUEIRA, 2006).

Microbiology: A sample of 25 g of compound sample was added to 225 ml of peptone water. Aliquots of 0.5 ml of the 10-4 and 10-5 dilutions were applied to Petri dishes containing nutrient agar (bacteriological analysis) and Sabouraund Agar supplemented with antibiotics (fungus analysis). The plates were incubated at 37 °C for 48 h. The results were presented in UFC g^{-1} (SIQUEIRA, 2006).

2.4 Characterization of the Compound

At the end of the process, the obtained compounds were analyzed for density in accordance with the method of self-compacting (RODELLA; ALCADRDE, 1994).

P, K, Ca, Mg, Na and organic matter were analyzed using the same method cited by EMBRAPA (2009). Fe, Cu, Mn and Zn were analyzed by atomic absorption.

3 RESULTS AND DISCUSSION

3.1 Monitoring of the Process

During composting a mesophilic initial stage was observed. As the process progresses, there is an increase in temperature due to microbial action, reaching 70°C (MARÍN; SANZ; AMILS, 2005). In the present work, a thermophilic phase was observed early with temperatures ranging from 48.9 to 56°C, even before the mesophilic stage, for all windrows. This unusuality may occur due to the piles reduced dimensions, which have a higher ratio of surface area and volume, and therefore greater heat loss from the surface (HAUG, 1993). The ambient temperature was approximately 30° C in all experiments.

The evaluation of the windrows pH value during the composting shows a similar behavior for all windrows, with an initial pH decreases followed by pH increases to 9.0 in approximately 28 days (RODELLA, 1994). In this study performed by Haug (1993), pH varied between 5.0 to 8.5. During the composting process, the formation of CO_2 and NH_3 neutralize the pH. The pH irregular level may be explained by the CO_2 loss to the environment due to the reduced dimensions of the windrows. However, at the end of the composting, these values (± 8.5) are within the range of theoretical idealism. Other authors working with different types of waste also observed alkaline pH values (TEJADA, 2001).

The composting piles with more market waste content had bigger Nitrogen content values. During the process, the piles had an increase in the concentration of total Nitrogen to a constant value occurring after approximately 30 days. This increase was approximately of 64.4%. The final concentrations were similar to those found by Jahnel et al. (1999) in the composting process using municipal waste. The increase in the percentage of pruning waste in the initial composition of the windrows resulted in higher concentrations of cellulose, hemicellulose and lignin. Comparing the levels of these fibers at the beginning and at the end of the maturation phase of the compound. It was observed a decrease in the levels of cellulose. For the windrow containing 30% of pruning waste, the reduction was of 34%, showing that the microorganisms responsible for the process were able to degrade cellulose. The results obtained from cellulose, hemicellulose and lignin are consistent with the results presented by Siqueira (2006).

Bacteria were prevalent at the beginning stages, while fungi are present in higher concentration in the initial mesophilic phase. At the final mesophilic step bacteria and fungus had their concentrations reduced, characterizing the near end of the composting process. At the beginning of the process the degraded substrates are consumed more easily, predominating the population of fermentative bacteria. As more degradable substrates are consumed, the carbon source is basically made up of complex carbohydrates (cellulose, hemicellulose and lignin), which are easily consumed by fungus, which produce enzymes such as cellulase and xylanase, responsible to degrade macromolecules and make them available to be assimilable by microorganisms, leading a microorganisms grow (SIQUEIRA, 2006). At the ed of the process, the concentration of bacteria was found reduced, while the amount of fungus remained high. Composting is finished when the temperature of the windrow is close to ambient temperature, due to low microbial activity (and pH and total Nitrogen are stabilization (KIEHL, 2002). In the data obtained during the monitoring it was observed that high level of pruning waste leads to more time to compost maturation. This can be explained by the low levels of total Nitrogen.

The windrow 1 was decomposed in 75 days; the windrow 2 in 83 days; the windrow 3 in 81 days; the windrow 4 in 90 days and the 5 windrow was decomposed in 95 days. Marín et al. (2005) and Andersen et al. (2011) found similar results that does not differ from the composting time observed in this study.

3.2 Characterization of Compound

The formed compounds were analyzed in relation to organic matter content, density, macro and micronutrients, as shown in Table 1.

Table 1 - Results of soil organic material, macro and micronutrients

PARAMETERS	WINDROWS					
	W1	W2	W3	W4	W5	SOIL*
Density ($g.dm^{-3}$)	0,59	0,56	0,56	0,50	0,45	1,47
Organic Matter ($g.dm^{-3}$)	96,8	110	87,6	94,4	115	22
Calcium ($cmol.dm^{-3}$)	7,77	8,3	8,15	7,89	12,9	0,6
Magnesium ($cmol.dm^{-3}$)	3,23	3,4	2,65	3,81	6,3	0,5
Sodium ($cmol.dm^{-3}$)	0,14	0,12	0,21	0,15	0,22	0,14
Potassium($cmol.dm^{-3}$)	0,8	0,49	0,83	0,79	1,52	0,05
Fhosphorus ($cmol.dm^{-3}$)	1,99	1,84	1,29	1,26	0,37	0,02
Iron ($mg.kg^{-1}$)	912	755	785	990	293	NA
Copper($mg.kg^{-1}$)	0,28	0,58	0,31	0,39	ND	NA
Manganese ($mg.kg^{-1}$)	22,5	25,8	20	12,4	12,2	NA
Zinc ($mg.kg^{-1}$)	21,1	31	20,5	17,6	15	NA

* Coastal Plain soil of the State of Sergipe. ND - Not Detected. NA - Not Analyzed.

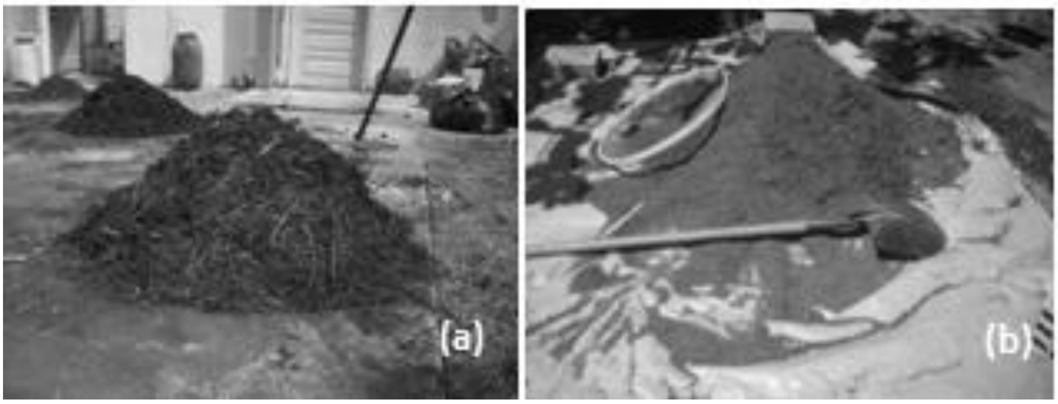
Density were lower higher quantities of pruning residue. This behavior was also observed by Stringheta (1997) studying the physical characteristics of substrates containing urban waste compost and carbonized rice hulls. According to Lacerda (2006) and Silva et al. (1997), high density soils with small structures and small soil porosity, are more restrict to plants development. The soil of the Coastal Plains of Sergipe stat has density of 1.47 $g.cm^{-3}$, resembling the sandy soil. Thus, the incorporation of the composting products can improve soil chemical a physical content.

Fanhini et al. (2004), Guerrini and Trigueiro (2004) and Hoffmann Junior (2007) obtained similar values to organic compounds density with the results found in this study. The results of organic matter, macro and micronutrients presented in the windrows of the present study were slightly lower than those obtained by other authors who have studied the process of composting using municipal waste in conventional scale (ALMEIDA, 2003; FACHINI; GALBIATTI; PAVANI, 2004). However, it was found satisfactory levels of an organic matter and Potassium in the Windrow 5, while Windrow 1 had high Phosphorus content. The generated compounds in this study showed satisfactory values of nutrients, especially when compared to the soils of the coastal plains of the state of Sergipe (CINTRA; LIBARDI, 1998).

3.3 Application of the Compound

The generated compound was donated to the SAME asylum located in Aracaju. In this asylum there is a garden where part of the food that constitute the meals for the elderly is produced. The compound was applied to mature and newly planted crops. There was no mortality and no apparent injury. Figure 1 (a) (b) shows the aspect of the windrow 5 during the composting process and ready to be used.

Figure 1 - Windrow 5 aspect during the process and ready to be used



Source: Prepared by the authors, 2019.

4 CONCLUSIONS

The monitoring of the composting process of municipal solid waste in small-scale showed maximum temperatures lower than the temperatures in the process of conventional scale, which was between 48.9 and 56°C. The other parameters, pH, degradation of Nitrogen, cellulose, hemicellulose, lignin and the microbial count had similar behavior to the conventional composting process and prove that small windrows size are not a limiting factor.

The pH obtained value 9.0, slightly above than observed in other studies, however within the range of ideality. There was an increase of 64.4% in the concentration of total Nitrogen due to the use of street market waste. The amount of macro and micronutrients of the produced compounds, as well as soil organic matter content, were higher than values obtained for the soil in the region of the Coastal Plains of Sergipe, highlighting the Windrow 1 and 5. The densities of the compounds had values considered satisfactory for plant development. It was concluded that small scale composting is a viable alternative to municipal solid waste disposal and can be use as organic fertilizer in farm and home gardens.

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